35 Combination Laser-Assisted Liposuction and Minimally Invasive Skin Tightening with Temperature Feedback for Treatment of the Submentum and Neck

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Abstract

Nonsurgical alternatives for addressing excessive fat and skin laxity of the submentum and neck are highly desirable treatment options. The purpose of this chapter is to present the combination of laser-assisted liposuction and minimally invasive skin tightening of submentum and neck under direct temperature control.

In a randomized, prospective, three-arm study of single laser-assisted liposuction and skin tightening (LAL-ST) treatment, 1064 nm, 1319 nm, and blended 1064/1319 nm were comparatively analyzed [1]. Subjects were randomized to three treatment arms. LAL was laser-fiber administered into the adipose layer, followed by aspiration. ST was laser-fiber administered into subdermal plane in multiple passes until uniform 45–48 °C was attained and total energy of 5000–7000 J was delivered. Subjects were photographed at baseline, and monthly posttreatment through 6 months, and assessed using four-point quantitative laxity grading scale and fat-aspirate quantitation. The mean percentage improvement in laxity grades was 43.8(18.5)% for 1064 nm, 36.6(5.9)% for 1319 nm, and 39.3 (12.9)% for 1064/1319 nm. The mean (SD) fat-aspirate volumes were 6.13 (3.28) mL for 1064 nm, 8.25 (2.50) mL for 1319 nm, and 6.50 (5.74) mL for 1064/1319 nm [1]. The results were comparable and the differences between the groups were not statistically significant. Combination temperature-controlled LAL-ST treats provide a nonsurgical treatment option for addressing excess fat and skin laxity of submentum and neck with excellent safety and efficacy.

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35.1 Introduction

The lower face and neck surgical lift involve not only the excision of skin to address skin laxity but also lipectomy to remove fat excess in the submentum and neck. Nonsurgical alternatives to surgical lifting have included traditional tumescent liposuction, laser-assisted liposuction (LAL), skin surface skin tightening (ST) technologies, and minimally invasive ST. Traditional tumescent and LAL of neck, while very effective at fat removal, failed to fully address the residual skin laxity [2–4]. In contrast to skin surface technologies, minimally invasive ST delivers energy directly into the dermis or subdermal plane via needle electrodes or by fiber cannula to treat lower face and neck laxity [5, 6]. In a randomized, blinded comparison to the surgical facelift, minimally invasive ST with fractional radiofrequency achieved 37 % the laxity reduction of the surgical facelift [6]. The combination of LAL and subdermal ST has been applied to the abdomen and more recently by the author to the submentum and neck [7, 8]. Therefore, combination laser fiber-mediated LAL-ST targets both fat excess and skin laxity in a nonsurgical approach to better approximate the clinical results of the surgical facelift.

LAL had been variably effective and associated with adverse events due to the lack of immediate in situ temperature feedback during the procedure. Until recently, skin surface thermography was used to estimate subdermal temperatures. This lack of direct temperature feedback bore unpredictable efficacy and complications such as dermal and epidermal thermal injury, blistering, burns, and subsequent adhesions [7–12]. By attaining and controlling ideal target temperature, the temperature feedback serves to maximize fat lysis and collagen denaturation for each step, without exceeding threshold temperatures that cause thermal burns. LAL and ST employing real-time temperature feedback with preselected, quantitative, uniform target temperatures throughout the fat and subdermal planes appear to improve efficacy and safety.

This approach was employed using a neodynium: yttrium aluminum garnet (Nd:YAG) laser that delivers via fiber cannula 1064 nm and 1319 nm, alone or in combination. In prior reports, it was hypothesized that the 1064-nm wavelength is responsible for lipolysis and 1319 nm for tissue tightening.

In a recent three-arm study, each wavelength was evaluated independently and in combination, for LAL and ST steps under direct temperature control [1]. Twelve subjects (Fitzpatrick skin types I–IV; eight women, four men; mean age 55.25 (SD ± 8.25, range 36–68) with submental and neck fat and skin laxity (minimum grade 2 on a four-point laxity grading scale, Table 35.1) were enrolled and randomly assorted by sequential allocation to receive treatment in one of the three treatment arms (Fig. 35.1). Subjects with excessive submental fat and neck laxity who consented to the study: age range 35–68; minimal submental laxity grade, 2 (Table 35.1) [1].

Table 35.1 Alexiades skin laxity grading scale

Grading scale	Descriptive parameter	Laxity
0	None	None
1	Mild	Localized to nl folds
1.5	Mild	Localized, nl and early ml folds
2	Moderate	Localized, nl/ml folds, early jowels, early sm
2.5	Moderate	Localized, prominent nl/ml folds, jowels and sm
3	Advanced	Prominent nl/ml folds, jowels and sm, early neck strands
3.5	Advanced	Deep nl/ml folds, prominent jowels and sm, prominent neck strands
4	Severe	Marked nl/ml folds, jowels and sm, neck redundancy and strands

Laxity grading scale. The grading scale has been tested and validated for determining laxity grade based on clinical findings. The scale was employed to evaluate laxity grades for each subject at baseline and each follow-up timepoint

nl nasolabial folds, *ml* melolabial folds, *sm* submental/submandibular

Fig. 35.1 Submentum–neck sections. The trapezoidal sections of the submentum and neck were marked with a skin marking pen prior to treatment. The area to be treated was bordered superiorly by the mental and mandibular borders, inferiorly by the superior border of the cricothyroid cartilage, and laterally by the medial borders of the sternocleidomastoid muscles. This area was subdivided into three equivalent sections as shown

35.2 Technique

35.2.1 Subject Preparation

The patient's face and neck should be photographed at baseline prior to treatment with standardized digital photography from front, side and three-fourth views. One hour prior to the procedure, mild sedation with diazepam 10 mg should be instituted. The patient is then prepared in a sterile fashion using benzalkonium chloride 1:750 and sterile draped. The treatment area is marked with a sterile pen extending from the submental and submandibular borders superiorly to the superior border of the cricothyroid cartilage inferiorly and to the medial aspect of the sternocleidomastoid muscles laterally. This marked three grids per neck corresponding to right, left, and center (Fig. 35.1).

35.2.2 Tumescent Anesthesia

Anesthetize the submental skin with 0.1 mL of 1 % lidocaine containing 1:200,000 epinephrine, which is injected intradermally into the center of the submental crease. With a no. 10 blade, a 1–2-mm incision is made in the anesthetized submental crease and extended in fat plane with blunt-tip (mini Metzenbaum) scissors. Tumescent anesthesia composed of 0.25 % lidocaine with 1:800,000 epinephrine buffered with 0.21 % sodium bicarbonate in lactated Ringer's solution and is injected using a 30-mL syringe with a 22–27 ½-gauge 1.5-in. spinal needle. Thirty milliliters of tumescent anesthesia is injected into the subcuticular layer of the submentum. A Byron tumescent 16-gauge infiltrating cannula attached to a Klein Tumescent Pump is introduced subcutaneously. Setting the pump at low (approximately 2), 150 mL of tumescent anesthetic is delivered uniformly into the subcutaneous space by dragging the cannula along the underside of the skin in radial extensions from the submental tip toward the superior border of the cricothyroid cartilage inferiorly, and the medial borders of the sternocleidomastoid muscles laterally, while staying inferior to the mandible to avert contact with the marginal mandibular nerve.

35.2.3 LAL Step

The thermometer (TempASSURE) accessory is connected to the neodynium: yttrium aluminum garnet (Nd:YAG) LAL system that delivers via fiber cannula 1064 nm and 1319 nm (Sciton ProLipo PLUS system, Sciton, Palo Alto, CA). A 1-mm laser cannula, 18 gauge, outfitted with a 1000-μm Bare Laser Fiber with Orb tip is inserted under the skin via the submental incision directed into the central marked section. The cannula is inserted and moved in a back-and-forth fanning pattern at a rate of 2–5 cm/s. The specified wavelength or blended ratio is selected on the device. This includes 1064 nm alone, 1319 nm alone, or a blend of 1064/1319 nm at 70 %:30 % as specified in Table 35.2. The laser energy is initially set at 8 W and applied in a first set of passes into the fat plane while monitoring internal temperature with TempASSURE. Once a temperature of >40 °C is attained, the laser energy is titrated down to 6–7 W. The laser passes are delivered in a fanning pattern to the central section until a uniform target temperature of 45–48 °C is attained

Table 35.2 Improvement submental and neck laxity grades before and after treatment and percentage improvement over baseline [1]

Subject ID	Grade[a]		Grade difference	Improvement (%)
	PreTx	PostTx		
1064 nm				
1	3	1	2.00	66.7 %
4	3	1.5	1.50	50.0 %
7	3	2	1.00	33.3 %
10	3.75	3	0.75	25.0 %
Mean	3.19 (0.38)	1.88 (0.85)	1.31 (0.55)	43.8 (18.5)%
1319 nm				
2	4	2.5	1.50	37.5 %
5	4	2.5	1.50	37.5 %
8	3.5	2	1.50	42.9 %
11	3.5	2.5	1.00	28.6 %
Mean	3.75 (0.29)	2.38 (0.25)	1.38 (0.25)	36.6 (5.9)%
1064/1319 nm				
3	3	2	1.00	33.3 %
6	3.5	2	1.50	42.9 %
9	4	3	1.00	25.0 %
12	3	1.5	1.50	50.0 %
Mean	3.38 (0.48)	2.13 (0.63)	1.25 (0.29)	39.3 (12.9)%
Overall Means	3.44 (0.43)	2.13 (0.61)	1.31 (0.36) $p<0.005$	39.4 (12.1)% $p<0.005$

Improvements in laxity grades for each subject, each treatment arm, and across the study. The pre- and posttreatment laxity grades, differences in laxity grades, and percentage improvement over baseline are presented for each subject, means for each treatment arm and means across the study along with statistical analysis

[a]Scale is shown in Table 35.1

throughout the central submentum section, no residual resistance is experienced when tunneling with the laser cannula, and a total of approximately 1000 J is delivered to each section. The cannula is then reinserted via the submental incision and oriented into one of the lateral sections. The procedure is repeated for each flanking trapezoidal marked section. A total of 2500–3500 J should be administered to the submentum and neck per subject during the LAL step.

35.2.4 Fat Aspiration

Once all three sections are treated to the target temperature and energy delivery and a uniform liquid consistency were attained, fat aspiration is conducted. A blunt-tipped Tulip Cannula is fitted to a 10-mL Toomey syringe. The liquefied fat is aspirated with gentle manual suction. The volume of fat aspirated should be recorded.

35.2.5 ST Step

A second set of laser passes is performed targeting the laser energy to the underside of the dermis while temperature monitored. The laser wavelength is selected on the device as 1064 nm alone, 1319 nm alone, or a blend of 1064 nm:1319 nm at 70 %:30 %. The laser energy is commenced at 7–9 W. The cannula is first introduced into the central section, followed by each flanking lateral section in series. The laser energy is titrated to a maximum of 10 W and to a minimum of 5 W as determined by the rate of heating. The cannula is inserted and moved in a back-and-forth fanning pattern at a rate of 2–5 cm/s within the trapezoidal section. The passes must be administered within each section until target temperature of 45–48° is attained uniformly throughout the section and a total of 800–1500 J are administered. The cannula is then inserted in each of the lateral sections flanking the central section and the process is repeated.

A total of 2500–3500 J should be administered to the total submentum and neck in the ST step.

35.2.6 Postoperative Management

The submental incision is closed with a single superficial interrupted 5.0 nylon suture and a Tegaderm dressing applied. A head and neck compression garment should be applied and worn for 3 days postoperatively. Mild pain relievers are prescribed during the first 24 h postoperatively, including acetaminophen or acetaminophen with codeine q 6 h prn.

35.2.7 Follow-Up

Patients should be assessed at 24 h, 1 week, and up to 6 months after procedure with photographs of the face/neck in frontal, three-quarter, and side views.

35.3 Results

35.3.1 Efficacy of Skin Laxity Reduction

The mean (SD) percentage improvement in laxity grades was 43.8(18.5)% for 1064 nm, 36.6 (5.9)% for 1319 nm, and 39.3 (12.9)% for 1064/1319 nm. The mean (SD) fat-aspirate volumes were 6.13 (3.28) mL for 1064 nm, 8.25 (2.50) mL for 1319 nm, and 6.50 (5.74) mL for 1064/1319 nm. The results were comparable and the differences between the groups were not statistically significant (Table 35.2). Across the entire study population, the mean pre- and posttreatment laxity grades were 3.44 and 2.13 for a mean grade difference of 1.31 and a 39.4 % mean grade improvement, which were statistically significant (Table 35.2). All subjects achieved at least 0.75 grade improvement in each treatment group (Table 35.2). Although the numbers in each group are insufficient for further statistical analysis, the data suggest a slight trend toward the greatest improvement in the 1064-nm treated group. Since the data were not all normally distributed, nonparametric tests were used to test for significant differences. If the pre- and posttreatment grades are compared for each group, the differences between arms are not significant ($p=0.1250$, 0.1250, and 0.1250 for 1064, 1319, and 1064/1319-nm combination, respectively) by the Wilcoxon signed-rank test. The Kruskal–Wallis test for differences in percentage improvement between the three groups was not significant. If the data in the three groups are combined ($n=12$), the median posttreatment grade is significantly lower than the median pretreatment grade ($p=0.0005$).

35.3.2 Efficacy of Fat Lysis

The mean fat aspirates were 6.1 (3.3) mL for 1064 nm, 8.3 (2.5) mL for 1319 nm, and 6.5 (5.7) for 1064/1319 nm blend. The mean volume of fat aspirate obtained across the study was 7.0 (3.8) mL.

35.3.3 Clinical Outcomes

The clinical improvements are highly consistent across all subjects (Figs. 35.2, 35.3, and 35.4). As shown in the serial photographs, the fat removal is observed by 1-month follow-up with progressive improvement in skin laxity through 6 months.

35.3.4 Safety and Recovery

Subjects will experience the following symptoms immediately postoperatively: edema, numbness, difficulty speaking, focal ecchymoses, and minimal erythema. The numbness and difficulty speaking resolve within several hours. During the first 24 h, discomfort is expected in the treated area, described best as "soreness," and is completely alleviated by pain relievers. The edema persists for approximately 2 weeks, with residual induration evident up to 3 months. Focal ecchymoses resolve within 7 days. Erythema resolves within 2–3 days. Erythema and warmth or tenderness extending inferiorly to the treatment area on the neck or worsening over the course of the first postoperative day are signs of infection and should be evalu-

Fig. 35.2 (**a**) Preoperative. (**b**) Posttreatment following LAL-MIST with 1064 nm only. Subjects randomized to the 1064-nm treatment arm received a single LAL and MIST treatment wherein each step entailed laser energy at 1064-nm wavelength for both steps

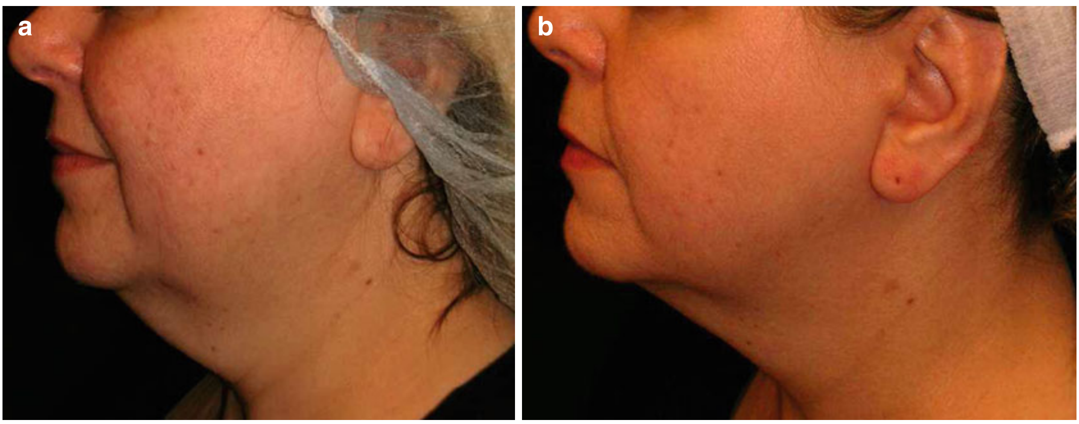

Fig. 35.3 (**a**) Preoperative. (**b**) Posttreatment following LAL-MIST with 1319 nm only. Subjects randomized to the 1319-nm treatment arm received a single LAL and MIST treatment wherein each step entailed laser energy at 1319-nm wavelength for both steps

ated and treated promptly. Treatment with a cephalosporin orally, such as cephalexin 250 mg po qid for 5 days, should result in prompt resolution of symptoms and signs within 24 h after commencing antibacterial antibiotic and complete resolution of erythema within 3 days.

35.4 Discussion

The protocol of combination LAL-ST with real-time temperature control and an Nd:YAG laser delivering 1064 nm, 1319 nm, or a combination of the two wavelengths via fiber cannula reported previously and described here is safe and effective in the treatment of both fat excess and skin laxity of the submentum and neck [1]. The protocol achieves a concurrent in situ uniform temperature of 45–48 °C in the targeted plane for the LAL and ST steps, with a total energy delivery of 5000–7000 J and yields consistent clinical improvements in both LAL and ST. The fat removal efficacy was similar for 1064 nm, 1319 nm, and the combination of the two wavelengths with a mean aspirate of 7.0 (SD 3.8; range: 3.0–15.0) mL per subject across the study.

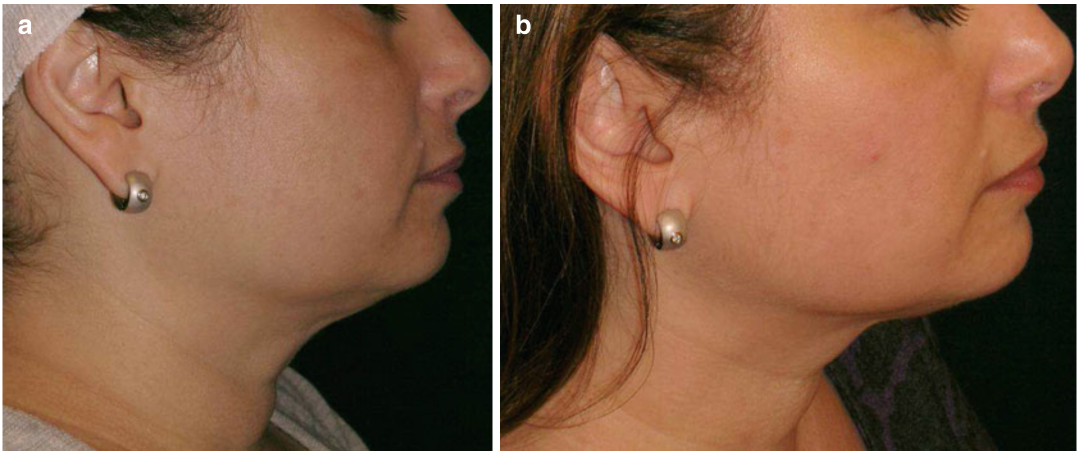

Fig. 35.4 (**a**) Preoperative. (**b**) Posttreatment following LAL-MIST with blended 1064/1319 nm. Subjects randomized to the 1064/1319-nm treatment arm received a single LAL and MIST treatment wherein the LAL step entailed a blend of 1064/1319 nm at a ratio of 70 %/30 % and the MIST step entailed a blend of 1064/1319 nm at a ratio of 30 %/70 %

Significant laxity reduction was observed across the study population with mean pre- and post-treatment laxity grades of 3.44 (SD 0.43) and 2.13 (SD 0.61), respectively, a mean grade difference of 1.31 (SD 0.36) and a mean percent grade improvement of 39.4 % (SD 12.1) over baseline, which were statistically significant ($p=0.0005$, Table 35.2). The percent improvements in laxity grade reductions were similar for 1064 nm, 1319 nm, or a combination of the two wavelengths. The real-time temperature feedback may be the explanation for the lack of thermal injury complications, suggesting that the in situ temperature feedback may improve the safety profile of LAL and ST.

In the past, tumescent liposuction, LAL, and ST have treated either fat excess or skin laxity, suggesting that a combination approach would be optimal. While traditional tumescent and LAL addressed fat excess and in selected patients also provided excellent recontouring, in many cases, the residual skin laxity resulted in poor patient satisfaction [2–4, 13]. While skin surface ST devices yield conservative efficacy, minimally invasive ST delivers energy directly into tissue via needle electrodes or fiber cannula which has increased efficacy in laxity reduction, achieving 37 % the laxity reduction of the surgical facelift in a randomized, blinded comparison trial [5, 6]. ST alone fails to address the submental or neck fat excess, which is excised during surgical facelift through lipectomy [6]. Combination LAL-ST has been applied to the abdomen to date [7, 8]. The protocol presented here demonstrates that combination LAL-ST safely and effectively targets fat excess and skin laxity to the submentum and neck.

The application of direct in situ temperature feedback and control to attain preselected uniform temperatures is an important advance to improve safety and efficacy of laser procedures. Skin surface temperature thermography had been used in the past for LAL to estimate temperatures in the subdermal plane, resulting in dermal and epidermal injury, thermal burns, blistering, and subsequent adhesions in numerous reports [8–11, 14]. In the current protocol, direct in situ temperature feedback was employed to maintain a uniform target temperature of 45–48 °C in the targeted plane (adipose layer or subdermal plane). Across the study, no incidence of thermal burn complications and consistent efficacy of at least 0.75 grades in each treatment group was observed (Table 35.2). The consistency of safety and efficacy may be a function of the control for uniform target temperatures precluding thermal burns and optimizing collagen denaturation.

Fat and laxity reductions appear to be similar whether 1064-nm or 1319-nm wavelength is employed for LAL and/or ST. The mean volumes of lysed fat aspirated ranged between 6.1 and 8.3 cc with an average of 7.1 mL across the three treatment arms. The small volumes obtained via this protocol are likely due to the restriction of the treatment area to the submentum. Most LAL studies do not report fat-aspirate volumes, particularly on the neck and submentum; though, one study calculated by mathematical modeling in the submentum a 5 mL volume reduction per 3000 J delivered [15]. This is consistent with the data presented here, wherein an average of 7 (range 3–15) mL is obtained after a total energy delivery of 5000–7000 J. In addition, manual aspiration was used as opposed to mechanical, which may account for differences in amount aspirated, when comparing to aspirates from abdominal cases. Laxity reductions were also found to be similar for the two wavelengths with mean laxity grade reductions ranging from 1.25 to 1.38 (average 1.31) on the four-point laxity grading scale. These findings suggest that either 1064 nm or 1319 nm or a combination of the two are similar in efficacy for the treatment of fat excess and skin laxity to the submentum and neck.

The protocol presented here is the first clinical comparison of the 1064-nm and 1319-nm wavelengths, either alone or in combination for LAL and ST. A combination of 1064-nm and 1319-nm wavelengths for lipolysis was shown to result in ST on the abdomen; however, these protocols involve a blend of the two wavelengths without temperature control [14–18]. It had been hypothesized that 1064-nm wavelength was responsible for melting the fat while the 1319-nm wavelength was responsible for the tissue-tightening effect, though these hypotheses had not been tested. Surprisingly, the current findings do not support the hypothesis that 1064 nm would be more effective at fat lysis and 1319 nm more effective at skin tightening. While the sample size in each arm did not detect statistically significant differences among the three arms, a slight trend toward greater efficacy in skin laxity reduction was observed for 1064 nm. A skin-tightening effect of 1064 nm had been suggested before by Badin [14], hypothesizing that the thermal effect resulted in collagen contracture. Histological evaluation of LAL demonstrated rupture of adipocytes accompanied by some collagen coagulation [16]. The slight trend toward greater efficacy of 1064 nm and the lack of statistically significant differences among 1064 and 1319 nm are unexpected findings and deserving of further study.

Several wavelengths have been employed for LAL, though the protocol presented here presents a randomized clinical comparison among wavelengths. One histologic study in the porcine model compared three continuous wave lasers at 980, 1370, and 1470 nm and three pulsed lasers at 1064, 1320, and 1440 nm [19]. No statistically significant differences in neocollagenesis were detected, but continuous-wave lasers were associated with greater hemorrhage [19]. A retrospective LAL study of 980 nm showed clinical ST, with ultrasound-detected changes in collagen [20]. Three separate clinical studies evaluating 1064 nm, 1320 nm, and the two wavelengths combined were compared [12]. LAL with 1064 nm showed no difference from tumescent liposuction alone. A second showed no difference between 1064 and 1320 nm. A third indicated that combination of 1064 and 1320 nm demonstrated fat and skin laxity reduction [12]. The findings from the published study of the current protocol appear to be consistent with these prior reports in showing no statistically significant difference between 1064 and 1319 nm or the combination of the two in the treatment of fat excess or skin laxity.

Wavelength-dependent effects on lipolysis and heat diffusion have been evaluated in porcine skin for 1064, 1320, and 1444 nm. Fat and water absorption analyses for neodymium-doped LAL reveals low and slightly higher absorption coefficients for fat and water for 1064 nm and 1320 nm, respectively [21, 22]. Recently, it was shown that 1,064 and 1,320 nm LAL does not work through selective photothermolysis of fat; rather, collagen or water within fibrous tissue septae is preferentially targeted by these wavelengths with injury to adjacent adipocytes occurring secondarily [21]. The thermal diffusivity, the relative measure of heat conduction through tissue, is lowest at 1444 nm, intermediate at 1064 nm, and greatest at 1320 nm [23]. In contrast, thermal confinement, heat localization near the source of laser irradiation, is greatest at 1444 nm, intermediate at 1064 nm, and least at 1320 nm [23]. Greater thermal confinement from 1444 nm or 1064 nm and the stricter limitation of the potential for collateral thermal injury may be of clinical benefit during LAL of confined areas such as the submentum and neck [23, 24]. The potential for undesirable collateral thermal injury is higher during LAL of facial structures (e.g., melolabial folds, jowls) where target tissue volumes are much smaller and where nerves are easily damaged [23]. Another recent study demonstrated greatest ablation crater depth and width and mass removal in porcine fat at the 1444-nm wavelength followed sequentially by 1320 and 1064 nm [24]. Thus, while the clinical data comparing 1064, 1320, and 1444 nm have yet to firmly establish differences in fat removal or ST efficiency, the basic science data are beginning to reveal rankings of ablative and thermal properties among the wavelengths that may impact usage in particular anatomic areas such as submentum and neck.

Other combination procedure LAL protocols have been employed in the past. Neck liposuction has been combined with laser resurfacing and platysmal muscle plication [25]. Tumescent liposuction has also been combined with CO_2 laser to the subdermal tissue with descriptive improvement [13]. The current protocol combines LAL with ST but offers the ease and facility of a single device, single laser cannula, single entrance point, and, as demonstrated, that fact that both steps may be performed with a single wavelength. The single 2-mm entrance point in the submentum heals without sequelae, offering a nonsurgical option with rapid recovery and excellent posttreatment cosmesis.

Conclusions

In sum, combination LAL-ST under immediate in situ temperature control appears to improve safety and possibly efficacy in treating fat excess and skin laxity of the submentum and neck. This protocol results in consistent improvement with similar efficacies in fat removal and laxity reductions with either 1064 nm or 1319 nm or a combination of the two wavelengths as a nonsurgical alternative for this anatomic region.

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